BIKTARVY®
bictegravir 50mg/emtricitabine 200mg/
tenofovir alafenamide 25mg tablets

BIKTARVY® combines the INSTI bictegravir with FTC/TAF, helping PLHIV achieve durable* treatment success:[1,2]

- **High efficacy[†] with 0 resistance[‡]** through 144 weeks in treatment-naïve PLHIV[2]
- **Well tolerated[§]** with significantly fewer all-grade treatment-related AEs vs ABC/3TC/DTG (secondary endpoint) through 144 weeks, with similar low rates of treatment discontinuation and serious AEs in both arms[‖#2]
- **Small** STR[¶] with **flexible** daily dosing[1]

* Durability in HIV is defined as maintained efficacy, which is dependent on patient adherence. Adherence is impacted by tolerability and simplicity of treatment.[3,4-7]

† At Week 144, in Study 1489 (BIKTARVY® [n=314] vs ABC/3TC/DTG [n=315]) efficacy was 82% vs 84% (95% CI: –2.6 [–8.5–3.4]) and in Study 1490 (BIKTARVY® [n=320] vs DTG + FTC/TAF [n=325]) efficacy was 82% vs 84% (95% CI: –1.9 [–7.8–3.9]), with BIKTARVY® demonstrating non-inferior efficacy vs comparator in both trials.[2]

‡ At Week 144, in pooled data from Study 1489 and Study 1490 in treatment-naïve patients, there were 0 cases of treatment-emergent resistance in the BIKTARVY® (n=0/834), ABC/3TC/DTG (n=0/315) and DTG + FTC/TAF (n=0/325) groups.[2]

§ At Week 144, in pooled data from Study 1489 and Study 1490 in treatment-naïve patients receiving BIKTARVY®, the most frequently reported adverse reactions (≥5%) were nausea 4%, headache 5% and diarrhoea 5%.[2]

‖ At Week 144, in pooled data from Study 1489 and Study 1490 in treatment-naïve patients receiving BIKTARVY®, any drug-related AE was reported in 26% for BIKTARVY®, 42% for ABC/3TC/DTG and 29% for DTG + FTC/TAF. BIKTARVY® had significantly lower rates of study drug-related AEs, nausea and study-drug related nausea than DTG/ABC/3TC ($p<0.001$).[2]

At Week 144, in pooled data from Study 1489 and Study 1490 in treatment-naïve patients, AEs leading to discontinuation were reported in 1% (n=6/634) for BIKTARVY®, 2% (n=5/315) for ABC/3TC/DTG and 2% (n=6/325) for DTG + FTC/TAF groups.[2]

¶ Each BIKTARVY® tablet is approximately 15 mm x 8 mm.[1]

3TC, lamivudine; ABC, abacavir; AE, adverse event; BIC, bictegravir; CI, confidence interval; DTG, dolutegravir; FTC, emtricitabine; INSTI, integrase strand transfer inhibitor; PLHIV, people living with HIV; STR, single-tablet regimen; TAF, tenofovir alafenamide.

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ORIGINAL RESEARCH

Sexual risk and HIV testing disconnect in men who have sex with men (MSM) recruited to an online HIV self-testing trial

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Objectives

We report the frequency of previous HIV testing at baseline in men who have sex with men (MSM) who enrolled in an HIV self-testing (HIVST) randomized controlled trial [an HIV self-testing public health intervention (SELPHI)].

Methods

Criteria for enrolment were age ≥ 16 years, being a man (including trans men) who ever had anal intercourse (AI) with a man, not being known to be HIV positive and having consented to national HIV database linkage. Using online survey baseline data (2017–2018), we assessed associations with never having tested for HIV and not testing in the previous 6 months, among men who reported at least two recent condomless AI (CAI) partners.

Results

A total of 10 111 men were randomized; the median age was 33 years [interquartile range (IQR) 26–44 years], 89% were white, 20% were born outside the UK, 0.8% were trans men, 47% were degree educated, and 8% and 4% had ever used and were currently using pre-exposure prophylaxis (PrEP), respectively. In the previous 3 months, 89% reported AI and 72% reported CAI with at least one male partner. Overall, 17%, 33%, 54%, and 72% had tested for HIV in the last 3 months, 6 months, 12 months and 2 years, respectively; 13% had tested more than 2 years ago and 15% had never tested. Among 3972 men reporting at least two recent CAI partners, only 22% had tested in the previous 3 months. Region of residence and education level were independently associated with recent HIV testing. Among current PrEP users, 15% had not tested in the previous 6 months.

Conclusions

Most men in SELPHI, particularly those reporting at least two CAI partners and current PrEP users, were not testing in line with current UK recommendations. The results of the trial will inform whether online promotion of HIVST addresses ongoing testing barriers.

Keywords: HIV, men who have sex with men, risk of HIV infection, self-testing

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Introduction

There is clear value for people living with undiagnosed HIV infection in ascertaining their HIV status so that antiretroviral therapy (ART) can be initiated as early as possible, which has benefits both for the health of the individual [1,2] and for the wider population as a consequence of reduced transmission risk [3,4]. However, low

diagnosis rates remain the largest gap in terms of achieving the Joint United Nations Programme on HIV/AIDS (UNAIDS) 90–90–90 goals, i.e. 90% of people with HIV know their HIV status, 90% of people who know their HIV-positive status access treatment, and 90% of people on treatment have a suppressed viral load [5]. It is estimated that 25% of the global population with HIV infection remain undiagnosed [6], which contributes disproportionally to new transmissions.

In the UK, men who have sex with men (MSM) remain the group at highest risk of HIV infection. In recent years, however, there has been a reduction in HIV incidence in MSM, largely as a consequence of increased frequent HIV testing, rapid ART initiation following HIV diagnosis, and expanded use of pre-exposure prophylaxis (PrEP) among HIV-negative people [7,8,9]. The number of HIV diagnoses in MSM fell from 3165 in 2014 to 1908 in 2018 (a 40% reduction) in the UK overall, and from 1523 to 736 in London (a 52% reduction) [8,9]. In 2018, each component of the 90–90–90 target was exceeded, reaching levels of 92–98–98 nationally [8].

Both international and national UK guidelines recommend that MSM test annually for HIV and more frequently if at higher risk, and it is recognized that increasing levels of HIV testing in MSM remains key to reducing incidence [10,11]. However, levels of ever and repeat HIV testing in UK MSM do not meet these testing recommendations, with studies reporting that 28% of MSM had never tested and only 55% tested annually [12,13]. There are particular issues around meeting the 3-monthly testing recommendation for MSM at higher risk of HIV infection – those who have had recent condomless anal intercourse (CAI) with partners of unknown or serodifferent HIV status, and/or use drugs during sex (chemsex). A 2016 study reported that only 27% of men considered at "higher risk" of HIV infection tested even 6-monthly (12). In addition, it was estimated that 8.6% of MSM with HIV infection in the UK remained undiagnosed in 2017 [8].

There has been increasing interest in the potential of HIV self-testing (HIVST) to improve rates of ever and repeat testing [14]. HIVST enables the person not only to take the sample but also to process it themselves, so that, at the time of testing, only they are aware of the result. The potential advantage of HIVST is that it may address structural and psycho-social barriers to testing [15-18], including stigma and concerns around privacy and confidentiality, and that it offers time saving and autonomy. HIVST may enable MSM who test suboptimally to meet norms around testing expectations which they might not otherwise be able to meet [19]. HIVST is also a viable means to support PrEP provision, where guidelines recommend 3-monthly HIV testing [20].

We report on the frequency of previous HIV testing and associated factors at baseline in MSM (including trans men) who opted to enrol in a large online HIV self-testing randomized controlled trial (RCT) [an HIV self-testing public health intervention (SELPHI)].

Methods

SELPHI was an internet based, open-label, randomized controlled trial (2017–2019), which aimed to assess effectiveness of providing free HIVST kits to increase HIV diagnosis rates. The full trial methods have been published previously [21]. In brief, SELPHI had a two-stage randomization with a target of enrolling 10 000 participants. Randomization A took place at enrolment, with eligible participants randomly allocated (in a 3:2 ratio) to the offer of a free baseline HIV self-test (BT) versus no offer of a free baseline HIV self-test (nBT) (Figure 1). Randomization B was open only to participants who met further eligibility criteria [21] and were randomized to receive regular HIV testing reminders and the offer of a free HIV-self test kit (RT) versus no regular self-test (nRT).

The SELPHI trial uses the BioSURE^{TM} (BioSure (UK) Ltd, Nazeing, UK) HIVST kit, an antibody immunoassay detecting HIV-1/2 antibodies from approximately 28 days after infection, requiring a whole blood sample from a finger prick. The HIVST kits were posted to participants by the manufacturer, using an address provided at enrolment.

Participants were recruited to the trial through sexual and social networking sites including Grindr, Hornet, Recon, Scruff and community Facebook webpages using advertising targeted to a broad spectrum of MSM and trans people which has been described previously [22]. Criteria for enrolment were: (1) age $\geq$ 16 years, (2) being resident in England or Wales, (3) being a man (including trans men) or trans woman, (4) ever having had anal intercourse (AI) with a man, (5) not being known to be HIV positive, and (6) having provided consent to link to the UK national HIV surveillance databases held by Public Health England. Very few trans women were recruited (n = 23) and they are not included in the current analysis and will be reported on separately.

This paper reports baseline data provided prior to randomization A. Data collected via an online survey at baseline included sociodemographics (gender, sexual identity, education, age, ethnicity and country of birth), recent sexual behaviour (numbers of AI partners and CAI partners in the previous 3 months), HIV testing history (time of last test, number of tests in the last 12 months and location of last test), sexually transmitted infection (STI) testing history, and PrEP and post-exposure prophylaxis (PEP) use. Postcode was collected to enable delivery

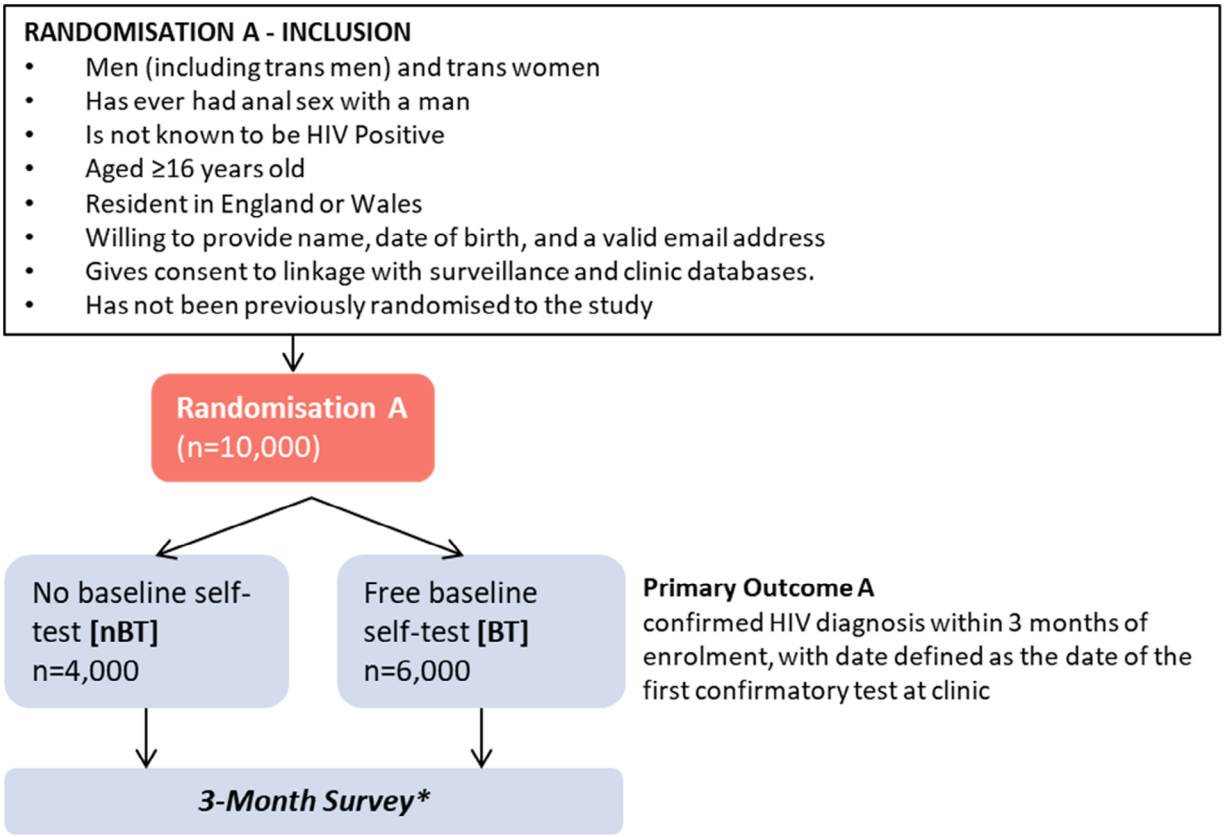

Fig. 1 The HIV self-testing public health intervention trial schema.

of the HIVST kit. This enabled calculation of (geodetic) distance to the nearest genitourinary medicine (GUM) (level 3) clinic using geographical information system (GIS) mapping data. Travel time from a participant's postcode to the nearest GUM clinic (at peak hours on Monday morning) was estimated for public transport (TRACC programme; www.basemap.co.uk/tracc) and for driving (ARCGIS PRO programme; www.esri.com/en-us/arcgis/products/arcgis-pro/resources). The analysis utilized public transport time for London and driving time elsewhere.

The study protocol was approved by the UCL Research Ethics Committee (REC) and informed consent was sought from all participants (ref: 9233/001).

Statistical analysis

Analyses were performed in STATA version 15.1 (StataCorp LLC, College Station, TX, USA). All analyses used data collected at baseline and prior to randomization. Two main analyses were performed. The first examined predictors of never having tested for HIV among all participants. The second examined predictors of not having tested in the 6 months prior to enrolment and included only men who reported two or more CAI partners in the 3 months prior to enrolment. The latter group are recommended to test quarterly according to UK guidelines, whether or not they are receiving PrEP. However, we used a conservative 6-month period for testing to allow for delays in appointments or attending.

Quantitative variables were classified into between three and five categories before associations with dependent variables were examined. Logistic regression analyses were based on participants with no missing data for any of the included variables (complete case analysis). Although this is less efficient than multiple imputation, the loss of efficiency is minimal as the frequency of missing data was low. For each variable, the category with the highest number of men was selected as the reference category. As ethnicity and being born outside of the UK were highly correlated, only ethnicity was included in the multivariable logistic regression models. Distance and travelling time to the nearest GUM clinic were also highly correlated, and the former was included in multivariable models. As the use of PrEP and the use of PEP were almost perfect predictors for having had an HIV test, these factors were not included in the multivariable model. The multivariable logistic

regression models included all listed variables, regardless of the *P*-value from the univariable analysis, because parsimony is an irrelevant consideration when the number of observations greatly exceeds the number of variables.

Because of the very large sample size, many highly statistically significant associations were found, even when the size of the effect was modest. It is therefore more informative to focus on estimates and confidence intervals rather than *P*-values. Interpretation of the logistic regression models is focussed on the adjusted odds ratios, that is, after controlling for any confounding effects of the other factors in the models.

Results

Baseline characteristics

Overall, 10 111 MSM were recruited to the trial, including 81 (0.8%) trans men (Table 1). The median age of participants was 33 years [interquartile range (IQR) 26–44 years]. Most men were of white British ethnicity (75.5%), followed by white other (14.0%), with 19.7% reporting that they had been born outside the UK. Most men identified as gay/homosexual (68.6%) followed by bisexual (8.6%); a large proportion (22.2%) either did not complete this question or selected the option "I don't usually use a term." Only 1.6% of participants were of black ethnicity and 4.3% of Asian ethnicity, despite recruitment strategies aimed at increasing participation from these ethnic groups. The majority of men recruited to the trial were highly educated, 47.1% having a university education and a further 11.2% reporting education beyond the age of 18 years. Overall, 83.7% of men lived within 10 km of a GUM clinic, with 72.3% having a travel time of ≤ 20 min and 91.1% a travel time of ≤ 30 min.

In the previous 3 months, 89.5% of men reported that they had had AI with at least one male partner and 27.9% reported AI with five or more partners in the previous 3 months. In terms of CAI partners, 70.0% of men reported at least one male partner in the past 3 months and 39.1% two or more partners. HIV or ART status of the partners was not available.

Overall, 12.1% of men had ever used PEP and 3.8% currently used PrEP. As expected, current PrEP use was mainly observed among men with at least two CAI partners in the previous 3 months (7.6% used PrEP), compared to those who did not report at least two CAI partners (1.4%). PrEP was only available in England and Wales during SELPHI enrolment through the Impact trial (England), through implementation pilots (Wales) and from online pharmacies. Of the 389 current users, 295 (75.8%) sourced PrEP via the

Table 1 Characteristics of participants at enrolment

Characteristic	All participants (n = 10 111)	At least two CAI partners in previous 3 months (n = 3952)
Region/country		
London	2509 (24.8)	938 (23.7)
SE England	1430 (14.2)	562 (14.2)
NW England	1357 (13.4)	576 (14.6)
Yorkshire/Humber	856 (8.5)	344 (8.7)
SW England	841 (8.3)	332 (8.4)
E England	765 (7.6)	294 (7.4)
W Midlands	711 (7.0)	287 (7.3)
E Midlands	661 (6.5)	294 (7.4)
NE England	376 (3.7)	162 (4.1)
Wales	599 (5.9)	209 (7.3)
Distance to nearest GUM clinic		
< 2 km	3014 (29.9)	1181 (30.0)
2–5 km	3895 (38.6)	1466 (37.2)
5–10 km	1743 (17.3)	708 (18.0)
≥ 10 km	1428 (14.2)	585 (14.8)
Travel time to nearest GUM clinic		
< 10 min	3770 (37.5)	1487 (37.8)
10–20 min	3505 (34.8)	1355 (34.4)
≥ 20 min	2787 (27.7)	1091 (27.7)
Age		
16–19 years	534 (5.3)	205 (5.2)
20–29 years	3301 (32.6)	1299 (32.9)
30–39 years	2883 (28.5)	1144 (28.9)
40–49 years	1919 (19.0)	770 (19.5)
≥ 50 years	1474 (14.6)	534 (13.5)
Sexual identity		
Trans gender	81 (0.8)	32 (0.8)
Gay/homosexual	6936 (68.6)	2656 (67.2)
Bisexual	867 (8.6)	328 (8.3)
Straight/heterosexual	31 (0.3)	4 (0.1)
Other	33 (0.3)	12 (0.3)
Not stated[†]	2244 (22.2)	952 (24.1)
Ethnicity		
White British	7594 (75.5)	3011 (76.6)
White other	1406 (14.0)	501 (21.7)
Black	161 (1.6)	79 (2.0)
Asian	437 (4.3)	155 (3.9)
Mixed	313 (3.1)	119 (3.0)
Other	150 (1.5)	66 (1.7)
Born outside UK	1993 (19.7)	735 (18.6)
Highest level of education		
School	4168 (41.7)	1776 (45.6)
Further education	1119 (11.2)	465 (11.9)
University	4706 (47.1)	1655 (42.4)
No. of AI partners in previous 3 months		
0	1064 (10.5)	-
1	2140 (21.2)	-
2–4	4081 (40.4)	1821 (46.1)
5–9	1894 (18.7)	1336 (33.8)
≥ 10	932 (9.2)	795 (20.1)
No. of CAI partners in previous 3 months		
0	2828 (30.0)	-
1	3330 (32.9)	-
2–4	2943 (29.1)	2943 (74.5)
5–9	700 (6.9)	700 (17.7)
≥ 10	309 (3.1)	309 (7.8)
PrEP		
Never	9310 (92.1)	3407 (86.3)
Past	406 (4.0)	239 (6.1)

Table 1 (*Continued*)

Characteristic	All participants (n = 10 111)	At least two CAI partners in previous 3 months (n = 3952)
Current	389 (3.8)	301 (7.6)
Ever used PEP	1210 (12.1)	650 (16.6)

Values are *n* (%).
AI, anal intercourse; CAI, condomless anal intercourse; E, east; NE, northeast; NW, northwest; SE, southeast; SW, southwest; W, west; GUM, genitourinary medicine; PEP, post-exposure prophylaxis; PrEP, pre-exposure prophylaxis.
Missing values (all participants, high-risk participants): region (6, 3), distance to clinic (31, 12), time to clinic (49, 19), ethnicity (50, 21), highest level of education (118, 56), number of CAI partners (1, 0) PrEP (6, 5) and PEP (83, 27). All other variables had complete data.
†Either question not completed or response "I don't usually use a term."

internet, 60 (15.4%) through participation in a trial, 12 (3.1%) by a private prescription, nine (2.3%) from a friend, and 13 (3.3%) via other or unspecified means.

Sociodemographic characteristics were similar in men who had at least two CAI partners in the previous 3 months compared to the overall sample, with the exception of sexual risk behaviours (by definition) and the use of PEP or PrEP.

HIV testing behaviours

Overall, 16.9% of men had tested for HIV in the 3 months prior to trial entry, 33.2% in the previous 6 months, 54.1% in the previous 12 months and 71.7% in the previous 2 years. It was reported that 13.0% of men had last tested for HIV > 2 years prior to trial entry and 15.3% had never tested for HIV (Table 2). Figure 2 shows the distribution of time since last HIV test by geographical region.

Among men with at least two CAI partners in the previous 3 months, only 22.6% had tested for HIV in the 3 months prior to entry to the trial; 58.8% had not tested in the previous 6 months and 11.5% had never tested (Table 2). Overall, 61.2% of men reported that their last HIV test was in a sexual health clinic, compared with 16.6% who had last tested via self-sampling and 6.7% via a self-test. Men with at least two CAI partners in the previous 3 months were slightly more likely to have had their last HIV test in a sexual health clinic, but there were no marked differences between the two groups for other venues. Of the 389 current PrEP users, 382 completed the question on time since last HIV test, of whom 56 (14.7%) had not tested in the previous 6 months.

Associations with never having been tested for HIV

Never having tested was least common in London (8.3%) and most common in Wales (27.0%), with proportions ranging between 14.6% and 18.7% across the English regions (Table 3). Never having tested was markedly higher among men aged 16–19 years [45.7%; adjusted odds ratio (OR) 3.54 compared with age 20–29 years]. Men aged 30–39 years were least likely to have never tested (9.4%). Sexual identity was a powerful predictor of never having tested, with an adjusted OR of 2.72 for bisexual men (31.2%) and 9.50 for heterosexual men (54.9%), compared with gay men, although the number in the latter category was small (n = 31). The comparatively large group who declined to state their sexual identity were slightly more likely never to have tested compared with gay men (adjusted OR 1.23). There was a gradient across level of education, with men whose highest level of education was to the age of 16 years only having an adjusted OR of 1.52 compared with men who attended university. There was no independent association between never having tested for HIV and ethnicity or distance or journey time (not shown) to nearest sexual health clinic. Neither previous PEP nor PrEP use was included in these models, as ever HIV testing was nearly ubiquitous in these groups (98.8% and 99.3%, respectively); this finding was as expected, as HIV testing comprises part of the clinical management package of these interventions.

Table 2 HIV testing characteristics at enrolment

Characteristic	All participants (n = 10 111)	At least two CAI partners in previous 3 months (n = 3952)
Never tested	1537 (15.3)	449 (11.5)
Time since last HIV test†		
< 3 months	1695 (16.9)	884 (22.6)
3–5 months	1628 (16.3)	729 (18.6)
6–11 months	2093 (20.9)	822 (21.0)
12–23 months	1764 (17.6)	648 (16.6)
> 24 months	1297 (13.0)	382 (9.8)
No. of HIV tests in previous 12 months (if at least one)		
1	2806 (52.3)	1116 (46.9)
2	1419 (26.8)	645 (27.1)
3	657 (12.7)	365 (15.3)
≥ 4	402 (7.6)	253 (10.6)
Venue of last HIV test		
Sexual health clinic	5089 (61.2)	2235 (65.6)
Hospital	415 (5.0)	136 (4.0)
Community service	347 (4.2)	127 (3.7)
Self-sample	1380 (16.6)	504 (14.8)
Self-test	556 (6.7)	212 (6.2)
Bar/pub/club/sauna	114 (1.4)	58 (1.7)
GP	294 (3.5)	102 (3.0)
Other	121 (1.4)	32 (0.9)

Values are *n* (%).
CAI, condomless anal intercourse; GP, general practitioner.
Missing values (all participants, high-risk participants): time since last HIV test (97, 38), number of tests in previous 12 months (141, 56), and venue of last test (161, 59).
†Denominator includes those never tested.

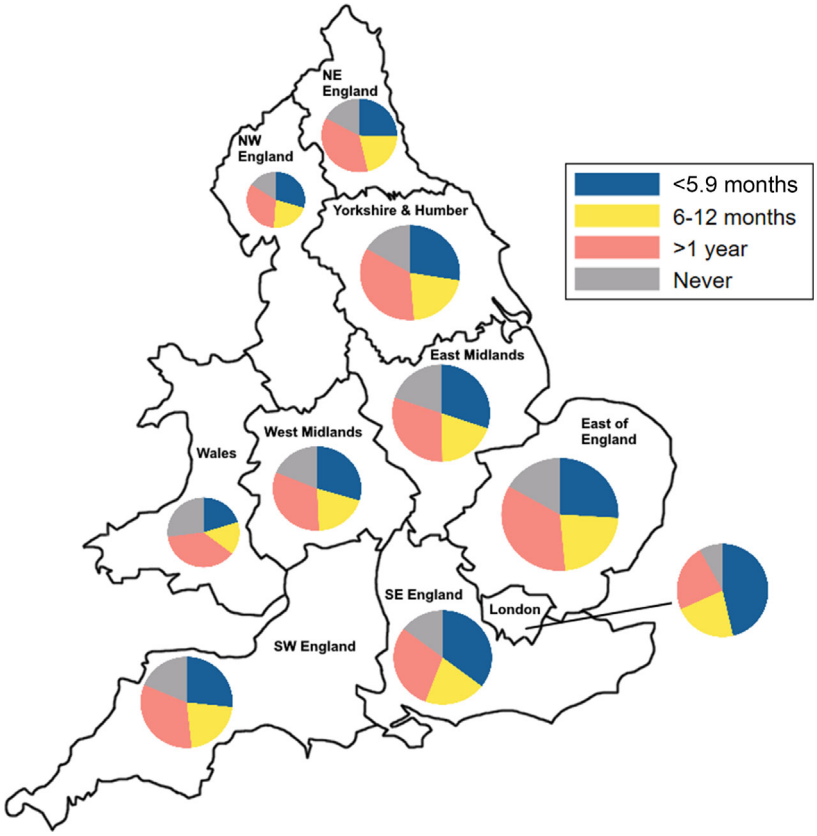

Fig. 2 Time since last HIV test by geographical region.

Associations with not having recently tested among men with at least two CAI partners in the previous 6 months

Similar, although not identical, associations were observed in a multivariable logistic regression analysis of not having had a recent (previous 6 months) test among men with at least two CAI partners in the previous 3 months (Table 4). Geographical region remained a strong predictor, although southeast England more closely resembled London in having a higher rate of recent testing, and northeast England joined Wales as the lowest ranking areas. A U-shaped relationship was again observed for the effect of age, although it was somewhat less pronounced, and the same strong gradient was evident for educational level. There was a difference in testing rates according to ethnicity, driven by higher rates of recent testing among the white other group, who were mainly white Europeans born outside of the UK (adjusted OR 0.77 compared to white British). A weak association was observed with distance to nearest GUM clinic, with a 17% lower odds of not having recently tested among men living within 2 km compared with those living between 2 and 5 km away. A noticeable finding was the lack of an association between recent testing and sexual identity in this group, in contrast to the analysis of never having tested.

Discussion

Among people enrolling in the SELPHI trial, the most striking finding was the relatively low rate of HIV testing among men with at least two CAI partners in the previous 3 months, who should, according to current UK recommendations on HIV testing frequency in MSM, be testing at least quarterly [11]. This recommendation is more frequent than current European guidance, which recommends testing at least annually [23]. Almost 60% of this high-risk group had not tested in the previous 6 months and 23% had not tested in the last 3 months. Even higher levels of infrequent testing were observed in certain regions (Wales and northeast England) and among less well-educated men. Among the men who were taking PrEP at the point of enrolment, approximately 15% had not tested in the previous 6 months, most of whom had sourced PrEP themselves [as a consequence of the current National Health Service England (NHSE) policy of not

Table 3 Logistic regression analysis of never having tested for HIV (all participants)

Factor	*n* (%)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	*P*-value
Region/country				
London	206 (8.3)	1.00 (ref)	1.00	< 0.001
SE England	206 (14.6)	1.89 (1.54, 2.32)	1.55 (1.24, 1.94)	
NW England	213 (15.8)	2.08 (1.70, 2.55)	1.70 (1.36, 2.12)	
Yorkshire/Humber	141 (16.6)	2.21 (1.75, 2.78)	1.74 (1.36, 2.24)	
SW England	155 (18.7)	2.55 (2.03, 3.19)	1.99 (1.55, 2.55)	
E England	127 (16.8)	2.23 (1.76, 2.83)	1.79 (1.38, 2.32)	
W Midlands	132 (18.8)	2.56 (2.02, 3.24)	2.11 (1.64, 2.73)	
E Midlands	127 (16.8)	2.74 (2.16, 3.48)	2.12 (1.63, 2.75)	
NE England	64 (17.2)	2.31 (1.70, 3.13)	1.73 (1.25, 2.40)	
Wales	161 (27.0)	4.10 (3.26, 5.16)	3.42 (2.66, 4.41)	
Distance to nearest GUM clinic				
< 2 km	390 (13.1)	0.88 (0.76, 1.01)	0.87 (0.75, 1.01)	0.19
2.1–5 km	566 (14.7)	1.00 (ref)	1.00	
5.1–10 km	315 (18.2)	1.29 (1.11, 1.51)	1.03 (0.87, 1.21)	
≥ 10.1 km	259 (18.4)	1.31 (1.11, 1.54)	1.02 (0.86, 1.22)	
Age				
16–19 years	241 (45.7)	4.03 (3.31, 4.89)	3.54 (2.88, 4.36)	< 0.001
20–29 years	568 (17.3)	1.00	1.00	
30–39 years	269 (9.4)	0.50 (0.43, 0.58)	0.53 (0.45, 0.62)	
40–49 years	222 (11.7)	0.63 (0.54, 0.75)	0.66 (0.56, 0.79)	
≥ 50 years	237 (16.3)	0.93 (0.79, 1.10)	0.89 (0.75, 1.06)	
Sexual identity				
Gay/homosexual	899 (13.0)	1.00 (ref)	1.00	< 0.001
Bisexual	267 (31.2)	3.02 (2.57, 3.54)	2.72 (2.29, 3.23)	
Straight/heterosexual	17 (54.9)	8.10 (3.98, 16.5)	9.50 (4.40, 20.5)	
Other	9 (27.3)	2.50 (1.16, 5.40)	2.03 (0.86, 4.76)	
Not stated	345 (15.7)	1.24 (1.08, 1.42)	1.23 (1.07, 1.42)	
Ethnicity				
White British	1249 (16.6)	1.00 (ref)	1.00	0.35
White other	142 (10.2)	0.57 (0.48, 0.69)	0.82 (0.67, 1.00)	
Black	25 (15.6)	0.93 (0.60. 1.43)	0.89 (0.56, 1.41)	
Asian	62 (14.3)	0.84 (0.64, 1.11)	1.06 (0.78, 1.44)	
Mixed	41 (13.1)	0.76 (0.54, 1.06)	0.80 (0.56, 1.15)	
Other	14 (9.5)	0.53 (0.30, 0.92)	0.82 (0.45, 1.49)	
Highest level of education				
School	850 (20.6)	2.13 (1.89, 2.39)	1.52 (1.34, 1.73)	< 0.001
Higher education	164 (14.8)	1.42 (1.18, 1.72)	1.29 (1.06, 1.57)	
University	508 (10.9)	1.00 (ref)	1.00	

The adjusted analysis was based on 9820 participants with complete data.

making it freely available through the NHS]. This is concerning, as regular testing is important in this group to quickly identify breakthrough infections and initiate full ART, and self-testing could fill an important gap in this regard. It also indicates the importance of providing PrEP through the NHS as part of a structured programme of care with regular HIV and testing prior to prescription of further supplies of PrEP.

In the UK, an estimated 3600 MSM were living with undiagnosed HIV infection in 2018 [8]. Starting ART at HIV diagnosis is now recommended for individual and public health benefit [24], and attaining a durably suppressed HIV viral load eliminates onward transmission of the virus [3,4,25,26]. Therefore, reducing the time from HIV infection to diagnosis in MSM remains a key objective for micro-elimination strategies, as up to 80% of all HIV transmissions are estimated to derive from those who are undiagnosed [7].

It is recognized that levels of ever or repeat HIV testing in UK MSM, although increasing, remain lower than recommended in guidelines, particularly in MSM at increased risk of HIV infection through CAI with multiple partners [9,26]. Frequent HIV testing (3-monthly) is an essential component for management of men taking PrEP. We found that 33 men currently taking PrEP who had at least two CAI partners in the previous 3 months had not tested for HIV in the 6 months prior to entering the study. A recent study used a discrete choice experiment (DCE) design to determine whether MSM preferred a remote HIV test option (self-sampling or self-testing) or to test through a health care professional. In this study, a small group of participants preferred HIV self-sampling

Table 4 Logistic regression analysis of not having an HIV test in the previous 6 months [for participants with at least two condomless anal intercourse (CAI) partners in the previous 3 months]

Factor	*n* (%)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	*P*-value
Region/country				
London	406 (43.8)	1.00 (ref)	1.00	< 0.001
SE England	305 (54.7)	1.55 (1.25, 1.91)	1.07 (0.84, 1.37)	
NW England	364 (63.8)	2.26 (1.82, 2.80)	1.50 (1.19, 1.91)	
Yorkshire/Humber	216 (63.7)	2.26 (1.74, 2.92)	1.37 (1.03, 1.83)	
SW England	222 (67.3)	2.64 (2.03, 3.44)	1.67 (1.24, 2.25)	
E England	189 (65.6)	2.45 (1.86, 3.23)	1.57 (1.15, 2.15)	
W Midlands	185 (65.1)	2.40 (1.82, 3.17)	1.54 (1.14, 2.09)	
E Midlands	148 (60.9)	2.00 (1.50, 2.67)	1.29 (0.93, 1.78)	
NE England	118 (72.8)	3.45 (2.38, 4.99)	2.17 (1.46, 3.23)	
Wales	146 (70.2)	3.03 (2.19, 4.19)	2.16 (1.51, 3.10)	
Distance to nearest GUM clinic				
< 2 km	610 (52.1)	0.79 (0.68, 0.92)	0.83 (0.70, 0.98)	0.03
2–5 km	840 (57.9)	1.00 (ref)	1.00	
5–10 km	467 (66.4)	1.44 (1.19, 1.73)	1.13 (0.92, 1.38)	
≥ 10 km	375 (64.8)	1.33 (1.09, 1.63)	1.02 (0.81, 1.27)	
Age				
16–19 years	143 (70.1)	1.72 (1.25, 2.37)	1.32 (0.94, 1.85)	0.06
20–29 years	745 (57.7)	1.00 (ref)	1.00	
30–39 years	635 (55.9)	0.93 (0.79, 1.09)	1.19 (1.00, 1.42)	
40–49 years	440 (58.4)	1.03 (0.86, 1.23)	1.23 (1.01, 1.50)	
≥ 50 years	338 (64.0)	1.31 (1.06, 1.61)	1.33 (1.06, 1.68)	
Sexual identity				
Gay/homosexual	1510 (57.2)	1.00 (ref)	1.00	0.25
Bisexual	208 (64.0)	1.33 (1.04, 1.69)	1.09 (0.85, 1.42)	
Straight/heterosexual	4 (100.0)	ND	ND	
Other	8 (66.7)	1.49 (0.45, 4.98)	1.12 (0.33, 3.81)	
Not stated	571 (61.1)	1.17 (1.01, 1.36)	1.19 (1.00, 1.41)	
Ethnicity				
White British	1848 (62.0)	1.00 (ref)	1	0.01
White other	224 (45.3)	0.51 (0.42, 0.62)	0.77 (0.62, 0.96)	
Black	41 (51.9)	0.66 (0.42, 1.04)	0.89 (0.54, 1.45)	
Asian	83 (53.9)	0.72 (0.52, 0.99)	1.19 (0.83, 1.72)	
Mixed	71 (59.7)	0.91 (0.62, 1.32)	1.36 (0.90, 2.05)	
Other	26 (40.0)	0.41 (0.24, 0.68)	0.54 (0.31, 0.93)	
Highest level of education				
School	1187 (67.6)	1.00 (ref)	1.00	< 0.001
Higher education	275 (59.8)	0.71 (0.58, 0.88)	0.83 (0.66, 1.04)	
University	809 (49.2)	0.47 (0.41, 0.54)	0.62 (0.53, 0.72)	
PrEP use				
Never	2183 (64.6)	1.00 (ref)	1.00	< 0.001
Past	82 (34.6)	0.29 (0.22, 0.38)	0.32 (0.24, 0.43)	
Current	33 (11.2)	0.07 (0.05, 0.10)	0.08 (0.06, 0.12)	

The adjusted analysis was based on 3819 participants with complete data.
AI, anal intercourse; CAI, condomless anal intercourse; E, east; NE, northeast; NW, northwest; SE, southeast; SW, southwest; W, west; GUM, genitourinary medicine; PEP, post-exposure prophylaxis; PrEP, pre-exposure prophylaxis; ND, not defined.

(HIVSS) or HIVST and they were more likely to have never previously tested, to be of non-white ethnicity and also to be current PrEP users than those who preferred facility-based testing [27]. Men were also reluctant to pay for HIVST and preferred testing options that were free at the point of delivery.

The motivations underlying testing behaviours in MSM, in particular in men who are not testing in line with the recommended frequency or who have never tested, are complex. Lack of testing may be attributable to structural barriers to obtaining an HIV test (e.g. clinics being difficult to access because of time constraints or capacity issues or distance); lack of knowledge about how to obtain a test; low perceived risk of HIV infection and individual psycho-social issues, including potential fear of the result, fear of needles or medical procedures, and issues around disclosure of homosexual activity and perceived stigma [15,17,27,28]. Individuals enrolled in this cohort in the knowledge that they would participate in an RCT of HIVST. This suggests that HIVST is acceptable to this cohort and may overcome some of these structural and psychological barriers.

Associations with lower levels of ever and repeat testing in our study suggest that targeting promotion and expanding testing opportunities in younger men and in those with lower levels of education may improve access to and uptake of HIV testing. Our results also suggest that HIVST may provide a route for HIV testing for men who are not gay identified, as these men were more likely to have never tested for HIV prior to entering the trial. This association of frequency of HIV testing and sexual identity has been noted in other studies in MSM which found that non-gay-identified MSM were least likely to have tested previously for HIV [26]. There is also a suggestion in our data that there are particular barriers to HIV testing for those who live outside London, most especially in Wales where provision of sexual health services varies hugely between regions [28]. HIVST may play a role in meeting unmet HIV testing needs in these areas.

There are several important considerations in interpreting the results of our study. First, the trial participants were, by definition, interested in HIV self-testing or may have been interested in testing in any case and should not be regarded as representative of the general MSM population. However, our analysis is important in understanding the profile of individuals to whom self-testing may have appeal. For example, when we designed the trial we were uncertain if the online advertising would mainly attract men who had never tested before (possibly through unwillingness to engage with the health care system) or who had tested before but saw self-testing as a more convenient testing modality. The fact that 85% of participants had previously tested points to the latter explanation being more dominant. However, this percentage varied markedly according to certain characteristics. A particularly strong effect was observed for age, with almost one half of men aged 16–19 years not having tested previously. Self-testing may be especially useful in motivating younger men to initiate regular HIV testing.

Secondly, only limited and brief questions were asked about previous HIV testing (time of previous test, number of tests in the previous 12 months and venue of the previous test) and sexual history (number of AI and number of CAI partners in the previous 3 months). Therefore, an individual who last tested 3 years ago, say, may not have been noncompliant with testing guidelines if he only recently started having sex again after a long period of celibacy or may have enrolled in SELPHI in order to obtain an HIV test following recent risk behaviour. Similarly, a partial explanation for the high rate of never testing among young men is that their sexual debut may have been a recent event. While it would have been desirable to ask more detailed questions, ideally linking historical testing behaviour to historical sexual behaviour, the priority was to keep the enrolment process short to maximize recruitment to the trial. Thirdly, we recruited low numbers of black minority ethnic and trans men, who are key groups at risk of HIV infection, which may make the results less generalizable [29,30].

In summary, we found that men with at least two CAI partners had been testing at lower than recommended levels at entry to an online HIVST trial. The current UK HIV testing policy in MSM focusses on increasing the rate of annual testing among all MSM, including those at lower risk of HIV infection [i.e. younger men, much older men ($\geq$ 65 years old) and non-gay-identified MSM] [8]. Instead, the results of our study suggest that promotion of more frequent testing among the groups most at risk of infection should be prioritized in order to reduce the time between infection and diagnosis. Our study suggests that free provision of HIVST could play a role in overcoming barriers to frequent HIV testing, and that online ordering for postal delivery is a feasible and acceptable means of delivery for MSM.

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Author contributions

AR, DD, FL, AP, FB and SMcC conceived the study and obtained funding. All authors contributed to study design and interpretation of the data. DD and LMcC performed the statistical analysis. AR and DD wrote the first draft of the manuscript. All authors commented on the manuscript and approved the final draft.

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